§19. Design Study of an Enhancement Superconducting Coil for the NIFS Superconductor Test Facility

Obana, T.

The superconductor test facility was constructed in the early 1990s at the National Institute for Fusion Science (NIFS) in order to develop a large aluminum stabilized superconductor for helical coils installed in the Large Helical Device[1]. In the test facility, characteristics of the superconductor immersed in liquid helium can be investigated under a maximum magnetic field of 9 T generated by superconducting split coils. However, the maximum magnetic field of the test facility is not sufficient to develop the superconductor used for a nuclear fusion reactor. Therefore, the design study of an enhancement superconducting coil for the test facility was carried out. In this study, the superconducting coil was designed while taking into account a magnetic field generated by split superconducting coils already installed in the test facility for the purpose of generating the maximum magnetic field of 13 T on the mid-plane.

Before the design of the enhancement superconducting coil was started, the magnetic field distribution generated by the split coil in each test space in which a superconductor is installed was investigated. The magnetic field distributions generated by the split coil with the test space of 100 mm, 320 mm, and 450 mm are shown in Fig.1. In the case that the test space is increased from 100 mm to 450 mm, the maximum magnetic field reduces from 9 T to 4 T on the mid-plane. Fig.2 illustrates the layout of the enhancement superconducting coil, and the split coil which can generate the magnetic field of 4 T on the mid-plane. As shown in Fig.2, the enhancement coil is located between the split coils. The configuration of the enhancement coil is split coil with 6 layers and 104 turns at one layer. As a candidate of a superconductor for the enhancement coil, an aluminum alloy jacketed Nb3Sn superconductor which has been developed by NIFS lately, was proposed. The size of the superconductor is 5 mm×17 mm, and 18 strands mad of Nb3Sn are installed in the aluminum alloy jacket[2]. An operating current of the enhancement coil is 5 kA which can generate the maximum magnetic field of 13 T on the mid-plane by using the split coil. A peak magnetic field on the coils approaches 17 T when the maximum field on the mid-plane is 13 T. The aluminum alloy jacketed Nb3Sn superconductor is not suitable under the high magnetic field. The current density of 60 A/mm^2 is necessary for a performance of a conductor to realize the magnetic field of 13 T. Consequently, a large increase of the Nb3Sn strands in the superconductor is essential to withstand the magnetic field of 17T.

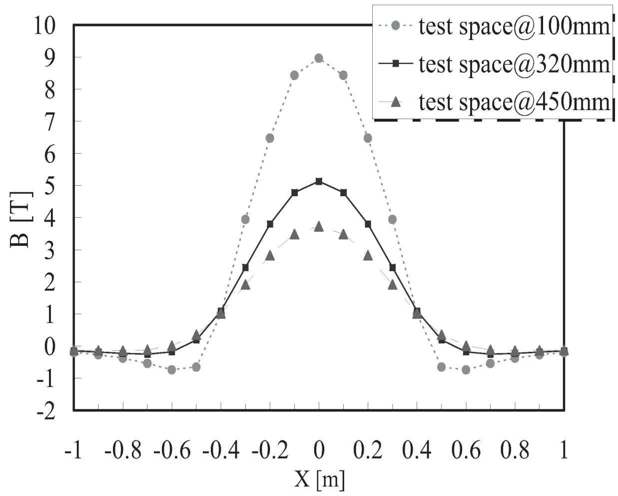

Fig. 1. Magnetic field distributions, which are generated by the split coil with each test space, on the mid-plane.

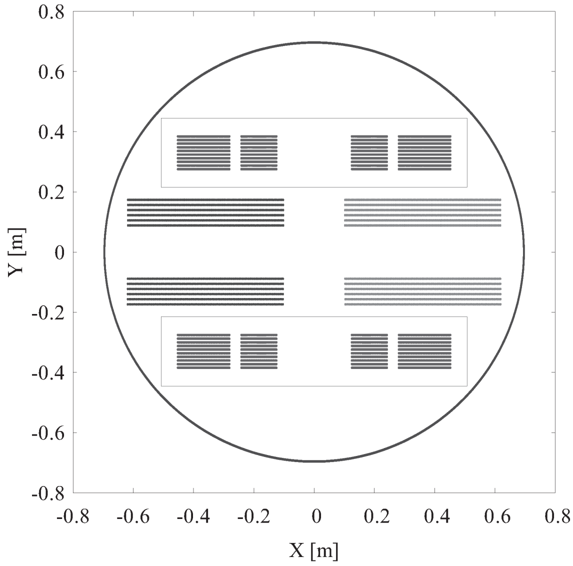

Fig. 2. Layout of the enhancement superconducting and split superconducting coil which can generate 4 T on the mid-plane.

1) J. Yamamoto, et al.: Fusion Engineering and Design, Vol. 20 (1993) p.147-151

2) K. Takahata, et al.: Abstract of CSJ Conference, Vol. 76 (2007) p.205